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Variation for biomass and residue production by dry pea

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Abstract

Pea (*Pisum sativum* L.) cultivars, grown for their dry edible seed, produce small and fragmentary harvest residues. The small residue pieces are ineffective in controlling soil erosion when the pea crop is followed by winter wheat in rotation. This presents a special problem for pea–wheat rotations common on the steep loess hills of the Palouse region of the U.S. Pacific Northwest. To determine the amount of residue produced by dry pea, total aboveground biomass was measured in plots of advanced pea yield trials conducted by the USDA at three locations in the Palouse region. Samples were collected in 1993, 1994 and 1995 and the amounts of residue produced were measured. Individual entries produced from 2300 to 4760 kg/ha of total biomass. Mean harvest indices for the nurseries ranged from 35% in 1994, a dry year, to 47% in both 1993 and 1995. Seed and residue yields were smaller in 1994 than in 1993 and 1995. Residue production and seed yield were influenced by sowing date and the amount and distribution of precipitation. Despite large environmental effects on residue production, sufficient genetic variation to improve the residue yields of dry pea was observed. The large, positive and significant correlation between seed yield and residue production indicated that it is possible to increase seed yields simultaneously with residue production through the incorporation of germplasm with greater potential for vegetative growth.

Keywords: USDA-NRCS, United States Department of Agriculture Natural Resource Conservation Service; USDA-ARS, United States Department of Agriculture – Agriculture Research Service; HI, Harvest index

1. Introduction

Current cropping practices threaten the sustainability of agricultural production in the Palouse region of the U.S. Pacific Northwest. Cropland in that region is characterized by slopes up to 45° that are extremely susceptible to soil erosion (Larson, 1979; Frazier et al., 1983; Moldenhauer et al., 1983). Soil losses due to water erosion frequently exceed 11 t ha^{-1} $year^{-1}$, the maximum rate determined by the USDA to allow for sustainable agriculture in this region (Larson, 1981). In 1978, the Palouse Cooperative River Basin Study report estimated average annual soil losses due to erosion in the Palouse region to be 31 t/ha and could be as high as 45 t/ha in the more highly erodible areas (Frazier et al., 1983). Larson (1979) estimated erosion in the Palouse region to be between 11 and 33 t/ha in 1975. Moldenhauer et al. (1983) suggested that as much as 225 t of soil can be eroded per hectare in a single event over a few days on the steep Palouse hills.

One effective method of reducing erosion is to maintain crop residues on the soil surface during

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periods of high precipitation. This is difficult to do given the crop rotations commonly used in high rainfall regions of the Palouse. The two main crop rotations currently used are: (1) winter wheat (*Triticum aestivum* L.) – spring wheat or barley (*Hordeum vulgare* L.) – spring legume, and (2) winter wheat – spring legume. The most severe erosion occurs when winter wheat is sown following a spring legume crop, such as dry pea (*Pisum sativum* L.) or lentil (*Lens culinaris* Medik.). Although pea and lentil crops produce sufficient amounts of straw to resist the erosive effects of rainfall and runoff due to snow melt, much of it is broken into such small fragments during harvest that it is not effective in holding soil (Muehlbauer, 1996).

The United States Department of Agriculture-Natural Resource Conservation Service (formerly the USDA-Soil Conservation Service) has developed guidelines for minimum amounts of residue that should remain on the soil surface. Following a crop of dry pea, 280 to 330 kg/ha of residue is required depending on the cropping system used and the average annual precipitation (USDA-SCS, 1992). Currently grown cultivars of dry pea and lentil are unable to meet these minimum requirements due to the brittle nature of the crop residue. Residues shatter into small fragments as the plants pass through the combine and most of it is either blown away or buried during tillage operations. Approximately 15% of the residue from legume crops remains on the soil surface after winter wheat has been sown. Even though grain legume crops serve an important role in rotations, growers may limit their use because of difficulties in meeting residue requirements. Therefore, to retain legumes in the rotation, cultivars capable of producing greater amounts of effective residue are needed.

The relationship between residue production and seed yields was determined for current breeding lines and cultivars. This relationship was used to determine the potential for simultaneously increasing seed and residue production. Environmental influences on plant growth and residue production were also determined.

2. Materials and methods

The plant material for this study consisted of the entries in the advanced green and yellow dry pea yield

Table 1
Entries included in the advanced green and yellow pea yield trials in 1993, 1994 and 1995

1993	1994	1995
Green cotyledon		
Alaska 81[a]	[b]	[b]
Columbian[a]	[b]	[b]
Campbell's Scotch[a]	[b]	
	Radley[a]	[b]
	Pro-2100[a]	[b]
PS710202		
PS810106	[b]	[b]
PS010376	[b]	
PS810102	[b]	
PS010840	[b]	
PS810098	[b]	
PS010838		
PS010896		
PS010363		
	PS110028	[b]
	PS110029	
	PS110105	
	PS110444	
	PS110462	
	PS210308	[b]
	PS210366	[b]
	PS210377	[b]
		PS210174
		PS210195
		PS210246
		PS210258
		PS210277
		PS210370
		PS310396
		PS310407
		PS310495
		PS310539
		PS310609
Yellow cotyledon		
Latah[a]	[b]	[b]
Umatilla[a]	[b]	[b]
	Rex[a]	[b]
	Scorpio[a]	[b]
		Capella[a]
PS010598	[b]	
PS010603	[b]	[b]
PS010843		
PS010844		
	PS110370	[b]
	PS110374	[b]
	PS110407	[b]
	PS110624	[b]
		PS210147
		PS210154
		PS210226
		PS210387a

[a] Named lines used as checks in the advanced green and yellow pea yield trials in 1993, 1994, and 1995.
[b] Designates the presence of the corresponding entry in that year.

trials conducted in the Palouse region (Table 1). They represent a relatively narrow range of plant types, but were derived from a wide genetic base. Several cultivars (Alaska 81, Capella, Columbian, Campbell's Scotch, Latah, Radley, Rex, Pro-2100, Scorpio, and Umatilla) were included in the trials each year as checks and served as a basis for comparisons among the advanced breeding lines. Four of the checks (Alaska 81, Columbian, Latah, and Umatilla) and two breeding lines (PS010603 and PS810106) were included in the trials each year. While the entries varied slightly in phenotype, most were tall (*LeLe*) and had a normal leaf type (*AfAfStStTlTl*). Up to five entries each year were either semi-dwarf or had an afila (leaflets converted to tendrils) leaf type (*afafStStTlTl*).

The number of entries included in the trials ranged from 18 in 1993 to 28 in 1994 to 34 in 1995 (Table 1). The yield trials were grown at Pullman (46°44′N, 117°11′W) and Farmington (47°5′N, 117°3′W), Washington, and Genesee, Idaho (46°36′N, 116°55′W). Pullman is 715 m above sea level (asl), Farmington is 756 m asl, and Genesee is 817 m asl. Soils at each of the three sites were from the Palouse series: fine-silty, mixed mesic Pachic Ultic Haploxerolls (USDA taxonomy).

The three sites, Pullman, Farmington, and Genesee, received 560, 420, and 460 mm of average annual (September to August) precipitation, respectively, over the 3 years of the study. Precipitation received during the growing season was greatest in 1995 followed by 1993 and 1994 (Table 2). Sowing dates for Pullman, Genesee, and Farmington, respectively, were 13, 10, and 12 May in 1993; while in 1994 the dates were 19 April, 28, and 28 March, respectively. Sowing dates in 1995 were 25 and 5 of April for Pullman and Genesee, respectively. Harvest dates for Pullman, Genesee, and Farmington, respectively, were 26, 20, and 27 August in 1993; 29, 18, and 29 July in 1994. Harvest dates in 1995 for Pullman and Genesee were 9 and 1 August, respectively.

Individual plots comprised six rows 5 m long spaced 0.3 m apart. Sufficient seed was sown to result in a plant density of 90 plants m^{-2}. Days to first flower were calculated as the difference between sowing date and the date when 50% of the plants had at least one flower. Days to maturity were calculated as the difference between the days to flower and when 90% of the plants were yellow and drying due to terminal drought (physiological maturity). The plots were considered to be at harvest maturity when all the plants were dry and the seeds could be easily threshed from the pods.

Just prior to harvest, samples of total aboveground biomass were collected by hand from a 0.3 to 0.4 m section of the second row in each plot (approximately eight plants per sample). Total aboveground biomass included leaves, stems, pods, and seeds. The samples were allowed to equilibrate to a uniform moisture content (ca. 7% moisture) via air drying. Each sample was then weighed, threshed, and the total aboveground biomass and seed yields recorded. The amount of

Table 2
Precipitation (mm) received during the fallow period prior to sowing and during the growing period at the Genesee, Idaho and Pullman, Washington locations in 1993, 1994 and 1995 and Farmington, Washington in 1993 and 1994

Location/year	Fallow period[a]	Growing period	Vegetative period	Reproductive period	Total
Genesee					
1993	353	142	72	70	495
1994	188	144	98	46	332
1995	354	213	89	124	567
Pullman					
1993	329	86	45	41	415
1994	204	109	76	33	313
1995	412	130	88	42	542
Farmington					
1993	398	218	85	132	616
1994	336	164	121	43	500

[a] The fallow period was from September of the previous year to the sowing date.

Table 3
Analysis of variance of straw production, seed yield and harvest index of dry pea lines in 1993, 1994 and 1995

Source	df	Straw yield			Seed yield			Harvest index		
		1993	1994	1995[a]	1993	1994	1995	1993	1994	1995
Block	2	7.72×10^{4}	$2.36 \times 10^{6\mathrm{e}}$	9.90×10^{5}	$2.28 \times 10^{5\mathrm{b}}$	$2.25 \times 10^{5\mathrm{f}}$	1.09×10^{5}	1.63×10^{-3}	$1.94 \times 10^{-2\mathrm{e}}$	1.31×10^{-3}
Cultivar[b]	17	$2.46 \times 10^{6\mathrm{f}}$	$1.08 \times 10^{6\mathrm{e}}$	$1.54 \times 10^{6\mathrm{f}}$	$1.29 \times 10^{6\mathrm{f}}$	$1.98 \times 10^{5\mathrm{f}}$	$4.78 \times 10^{5\mathrm{f}}$	$1.00 \times 10^{-2\mathrm{f}}$	$5.77 \times 10^{-3\mathrm{f}}$	$7.13 \times 10^{-3\mathrm{f}}$
Location	2	$1.82 \times 10^{7\mathrm{f}}$	$9.71 \times 10^{6\mathrm{f}}$	$4.15 \times 10^{6\mathrm{e}}$	$4.11 \times 10^{6\mathrm{f}}$	$4.81 \times 10^{6\mathrm{f}}$	1.75×10^{5}	$2.79 \times 10^{-2\mathrm{f}}$	$1.11 \times 10^{-1\mathrm{f}}$	$1.81 \times 10^{-2\mathrm{e}}$
C × L[c]	34	$5.29 \times 10^{5\mathrm{d}}$	4.55×10^{5}	6.93×10^{5}	$1.31 \times 10^{5\mathrm{f}}$	$6.58 \times 10^{4\mathrm{f}}$	$2.54 \times 10^{5\mathrm{f}}$	$1.96 \times 10^{-3\mathrm{e}}$	1.75×10^{-3}	$3.55 \times 10^{-3\mathrm{b}}$
C.V. (%)		24.1	27.6	22.3	8.5	11.9	8.8	8.6	13.1	10.5
R^2		0.64	0.44	0.56	0.88	0.79	0.78	0.65	0.59	0.54

[a] Data from 1995 are based on 2 locations (Pullman, WA and Genesee, ID).
[b] Degrees of freedom for Cultivar in 1993, 1994 and 1995 were 17, 27 and 33, respectively.
[c] Degrees of freedom for the Cultivar × Location interaction in 1993, 1994 and 1995 were 34, 54 and 33, respectively.
[d,e,f] Significantly different F at $p < 0.05$, $p < 0.01$ and $p < 0.001$, respectively.

residue produced by each subsample was determined by subtracting seed from the total biomass. Harvest index was calculated by dividing the seed yield by the total biomass of each sample (Donald, 1962). After the subsamples were removed from the plot, a small plot combine was used to harvest the entire plot. HI estimates obtained from the subsamples were then used to calculate total aboveground biomass and residue production for each plot from seed yields. The coefficients of variation (CV) for the harvest index estimates in 1993, 1994, and 1995 were 9, 13, and 10%, respectively (Table 3). The low values for these CVs indicate that the estimates are accurate despite the relatively small size (0.3 m of row) of the subsamples.

The trial at Farmington in 1995 suffered damage from a severe hail storm near harvest in early August that caused severe seed loss from shattering; thus the data from that location for that year were not included in the analysis. Statistical analyses were performed using the SAS Statistical package (SAS Institute, 1996). Analyses of variance were performed on individual years due to the number of different entries each year.

3. Results

Average residue production ranged from a low of 2940 kg/ha in the driest year, 1994, to 3390 kg/ha in 1993 (Tables 4 and 5). Residue production for individual entries ranged from 2300 kg/ha (Radley in 1994) to 4760 kg/ha (PS210387 in 1995) and differences among entries were statistically significant in all 3 years (Table 3). Farmington produced the least residue in 1994 and overall was the least productive site for seed yield and residue. Genesee produced the most residue (3290 kg/ha) followed by Pullman (3170 kg/ha). The breeding lines in the green pea trials in 1993 and 1994 produced greater residue and seed yield than the check cultivars; in 1995, however, the check cultivars produced greater residue yields and smaller seed yields than the breeding lines (Tables 4 and 5). The yellow pea breeding lines produced greater residue yields than the green pea breeding lines in all 3 years. HI values yellow peas were slightly lower each year due to greater residue production.

Seed yield in the trials was directly related to the environmental conditions each year. Average seed yields ranged from 1550 kg/ha in 1994 to 2900 kg/ha in 1993. Seed yield was most severely affected by the lack of precipitation during the latter portion of the growing period. In 1994, the average precipitation received during the reproductive period was 41 mm; while in 1993 and 1995 it was 81 and 83 mm, respectively. Seed yields in 1994 were approximately one-half those of 1993 and 1995 as was the amount of precipitation received.

Radley, a green cotyledon pea, produced the least seed yield (1070 kg/ha in 1994) while PS010603, a yellow cotyledon pea, produced the greatest seed yield (3480 kg/ha in 1993). Overall the yellow cotyledon peas produced greater seed yields in 1993 and 1994, while in 1995 the green peas produced slightly greater seed yields.

Harvest index values ranged from 35% in 1994 to 47% in both 1993 and 1995 (Tables 3 and 4). These values reflect the relative amounts of precipitation received during the reproductive period (Table 2). When additional moisture is available during the reproductive period, seed yields increase, which lead to larger harvest index estimates. HI values for the individual cultivars ranged from 32% (Alaska 81 in 1994) to 54% (PS210370 in 1995). Average HI values were 0–2% higher for the yellow cotyledon peas, but, these small differences were not significant.

The regressions of mean seed yield on mean residue production in 1993, 1994, and 1995 are presented in Fig. 1(a)–(c), respectively. It is evident from these figures that there were wide ranges of variation in seed and residue production and that environmental conditions in each year had a great influence on production. The slope (b) of the regression lines were similar in 1993 and 1994 (0.53 versus 0.49) while, in 1995, the slope was much flatter (0.15). The slopes of the regressions in 1993 and 1994 indicate that residues and seed yields can be simultaneously increased in a ratio of 2 : 1.

4. Discussion

Average seed yield and residue production differed each of the 3 years and was not related to the total amount of precipitation received during the growing

Table 4
Mean seed yields, residue production, harvest indices, and phenological data for the advanced green cotyledon dry pea yield trials at Genesee and Pullman in 1993, 1994 and 1995 and Farmington in 1993 and 1994

Trial	Checks/ Breeding lines	Total aboveground biomass (kg/ha)	Seed yield (kg/ha)	Residue yield (kg/ha)	Harvest index (%)	Days to flower	Days to maturity	Reproductive period
1993								
Genesee	Checks	6590	3030	3560	46	43	106	63
	Breeding lines	6860	3090	3770	45	45	104	59
Pullman	Checks	4810	2270	2540	48	39	106	67
	Breeding	5290	2580	2710	49	42	104	62
Lines								
Farmington	Checks	6240	2890	3350	47	41	106	65
	Breeding lines	6610	3030	3580	47	44	104	60
Mean	Checks	5880	2730	3150	47	41	106	65
	Breeding lines	6250	2900	3350	47	44	104	60
1994								
Genesee	Checks	4170	1590	2580	38	63	109	46
	Breeding lines	4540	1810	2730	40	62	108	46
Pullman	Checks	4200	1350	2850	32	50	93	43
	Breeding lines	4880	1650	3230	34	50	93	43
Farmington	Checks	4050	1290	2760	32	63	113	50
	Breeding lines	4020	1280	2740	32	62	114	51
Mean	Checks	4140	1410	2730	34	59	105	46
	Breeding lines	4480	1580	2900	35	58	105	47
1995								
Genesee	Checks	6160	2850	3310	46	62	110	49
	Breeding lines	5940	2950	2990	50	59	110	51
Pullman	Checks	7040	2760	4280	40	50	97	47
	Breeding lines	6180	2900	3280	47	48	97	49
Mean	Checks	6600	2800	3800	43	56	104	48
	Breeding lines	6060	2920	3140	49	53	103	50

season. For example, the Pullman location produced 37% greater seed yields in 1993 than in 1994 while receiving 21% less precipitation during the growing season. The even distribution of precipitation between the vegetative and reproductive phases of growth in 1993 and the uneven distribution in 1994, when only one-third of the precipitation was received during the reproductive period, explains the relationship between total precipitation during the growing season and seed yield. This same relationship was observed at Genesee and Farmington in 1994.

The effects of rainfall distribution and sowing date have been noted by Fletcher et al. (1966) and Martin et al. (1994). Martin et al. (1994) observed increased seed yields when rainfall was evenly distributed throughout the growing season. In 1994, seed yield and residue production at all three locations were markedly lower than during 1993 and 1995 with the

Table 5
Mean seed yields, residue production, harvest indices, and phenological data for the advanced yellow cotyledon dry pea yield trials at Genesee and Pullman in 1993, 1994 and 1995 and Farmington in 1993 and 1994

Trial	Checks/ Breeding lines	Total aboveground biomass (kg/ha)	Seed yield (kg/ha)	Residue yield (kg/ha)	Harvest index (%)	Days to flower (days)	Days to maturity (days)	Reproductive period (days)
1993								
Genesee	Checks	7590	3190	4400	43	46	102	56
	Breeding lines	7620	3030	4590	40	49	106	57
Pullman	Checks	5170	2370	2800	47	44	102	59
	Breeding lines	5870	2830	3040	48	48	106	58
Farmington	Checks	7430	3460	3970	47	47	102	55
	Breeding lines	6520	3030	3490	46	48	106	58
Mean	Checks	6730	3010	3720	45	46	102	56
	Breeding lines	6670	2960	3710	45	48	106	58
1994								
Genesee	Checks	4370	1850	2520	43	66	107	41
	Breeding lines	5010	1760	3250	37	67	107	60
Pullman	Checks	5190	1660	3530	33	53	91	37
	Breeding lines	5640	1760	3880	32	53	91	38
Farmington	Checks	3770	1320	2450	36	66	107	41
	Breeding lines	3840	1210	2630	33	67	107	40
Mean	Checks	4440	1610	2830	37	62	101	39
	Breeding lines	4830	1580	3250	34	62	102	40
1995								
Genesee	Checks	6180	2750	3430	45	64	107	43
	Breeding lines	5400	2380	3020	45	63	105	43
Pullman	Checks	8430	2770	5660	43	54	96	41
	Breeding lines	6010	2740	3270	46	53	96	42
Mean	Checks	7300	2760	4540	44	59	101	42
	Breeding lines	5710	2560	3150	46	58	100	42

exception of Pullman in 1993 (Tables 4 and 5). In 1993 and 1995, precipitation received was distributed evenly throughout the growing season while in 1994 the amount of precipitation received during the reproductive period was approximately one-half that received during the vegetative period. The uneven rainfall distribution in 1994 resulted in a pronounced terminal drought that reduced seed yields. Although precipitation was evenly distributed at Pullman in 1993, the overall amount of precipitation received was the least of any location resulting in lower residue amounts than expected.

Sowing date also had an impact on plant growth and production. The early sowing dates at all three sites in 1994, particularly Genesee and Farmington, reduced residue production despite receiving normal amounts of precipitation during the vegetative growth period. The 3-week delay in sowing at Pullman in 1994 allowed the plants an advantage with regard to residue production but the lack of precipitation late in the season reduced seed yield and lowered harvest index. The 1995 trial at Genesee was sown on 5 April and it was expected that residue production would be similar to the 1994 trials. However, sufficient moisture was received late in the growing season to allow normal seed development and residue production.

Dumoulin et al. (1994) and Summerfield and Roberts (1988) showed that temperature and photoperiod (which are related to sowing date in the temperate environments of higher latitudes) affect plant growth and development during the vegetative growth period. Shorter photoperiods and cooler temperatures slow the development of the crop and extend the period between sowing and flowering (the vegetative growth period). The period between sowing and flowering ultimately determines total accumulation of

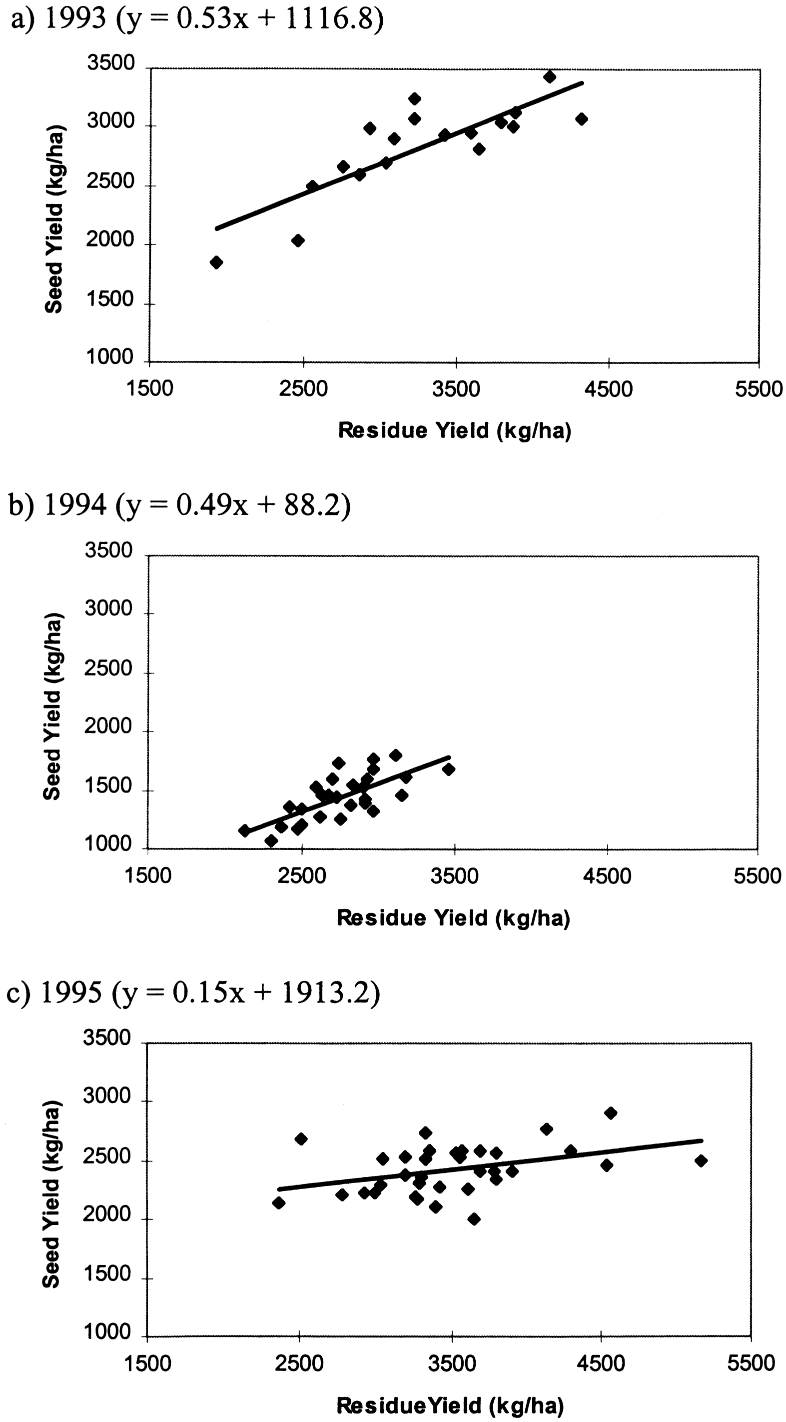

Fig. 1. Regression of mean seed yields onto mean residue yields for 18, 28 and 34 entries in the advanced green and yellow dry pea yield trials in 1993, 1994 and 1995, respectively

biomass because vegetative growth slows considerably or stops when flowering begins.

Trials sown prior to 15 April experienced much longer vegetative growth periods (61–64 days) and shorter reproductive periods (42–47 days) than those sown in late April or early May (Tables 4 and 5). These early-sown trials, with the exception of Pullman in 1993, produced the least residue despite having longer vegetative growth periods. These early-sown trials were exposed to cooler temperatures early in the vegetative growth period, which would have slowed growth and development. As mentioned earlier, the reduced amount of residue produced at Pullman in 1993 was due to the overall lack of precipitation during the growing season.

The length of the vegetative period was longer while the reproductive period was shorter for trials sown in late March and early April than for trials sown in early May. These results are consistent with the results of Dumoulin et al. (1994) who reported that the time to first flower was shorter for late sowing dates than for earlier once. The vegetative growth periods ranged from 43 to 46 days and the reproductive period ranged from 59 to 62 days. Although the vegetative period was nearly 20 days shorter for the later sowings, residue production was greater. The lengths of the vegetative period for the two trials sown in mid- to late April were intermediate to the trials sown earlier and later. The length of the reproductive period, however, was similar to earlier sowings.

Overall, the amount of variation in seed and residue yield among the entries was less in 1994 than in 1993 and 1995 (Fig. 1). The environment in 1994 prevented superior entries from expressing and realizing their maximum potential yield. The small slope value (b) in 1995 indicated that, although different from zero ($p = 0.01$), there was little relationship between seed yield and residue production. The entries in this trial were relatively similar in their potential seed yield but differed for the relative proportion of photosynthate partitioned to seed yield. Those entries that produced the least residue, but high seed yield, were the most efficient at partitioning photosynthate to the seed and would be valuable in a breeding program. In 1995, PS210370 had the most efficient partitioning ratio and was above the theoretical line with slope equal to one indicating that greater seed yield was produced per unit of vegetative biomass. The average harvest index for PS210370 in 1995 was 52% also indicating that greater seed yield was produced per unit of vegetative biomass.

The close proximity of the y-intercept (a) to the origin in 1994 indicated that the environment was indeed limiting and that the amount of seed produced per unit dry matter was near the minimum. The larger y-intercepts in 1993 and 1995 indicated that more favorable conditions allowed greater seed yields. The evaluations in different environments made it possible to identify lines with desirable and useful traits and lines that are widely adapted. Both types of lines are valuable in breeding programs.

New cultivars must produce equal or greater seed yields than existing cultivars whether residue production is increased or not. Increased grain yield in the cereal grains has generally been associated with greater partitioning to grain and an overall decrease in production of vegetative matter, thus increasing harvest index. Results from this study indicate that it is possible to not only maintain seed yield, but to increase seed yield simultaneously with residue production. The correlation between seed yield and residue production was 0.51 ($p > 0.001$), 0.34 ($p < 0.001$), and 0.40 ($p < 0.001$) in 1993, 1994 and 1995, respectively. This relationship will allow harvest indices to remain constant or possibly increase as the production of seed and residues are increased through breeding.

The wide range of variation for seed yield and residue production indicated that improvements have been made through past breeding efforts. Radley, a line released in the early 1980s, produced the least residue and seed yield while PS210387 and PS010603, two new cultivars released in 1997, produced the greatest amount of residue and seed yield, respectively. Both PS210387 and PS010603 have high harvest index values, 41% and 42%, respectively, which exceed the HI of Radley by 6 and 7%.

The results of this study corroborate those of others (Fletcher et al., 1966; Dumoulin et al., 1994; Martin et al., 1994), and indicate that variation exists for residue production, although it is strongly influenced by environmental conditions. In addition, the data reveal that seed yields can be increased simultaneously with residue production. Both adapted and exotic pea germplasms with the genetic potential to produce greater seed and residue yields are available. The use of these lines in hybridization programs in combination with appropriate selection criteria will result in greater seed yields and availability of greater residues for erosion control.

Although this study indicates that the amount of residue produced by the pea crop can be increased, it does not address the issue of residue structure and quality with regard to decreasing the amount of residue lost during combining, wind and tillage operations. Research is currently underway to evaluate the variation for total biomass and residue production in a larger number of more diverse pea germplasm accessions and to identify those which possess useful characteristics such as higher lignin concentrations and stronger stems.

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